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# Molecular phylogeny of the genus *Goniopora* and taxonomic revision of the family Poritidae (Cnidaria: Scleractinia)

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## Abstract

## Introduction

Recent molecular-based phylogenetic analyses cast doubt on the traditional morphological-based taxonomy in the zooxanthellate scleractinian corals. Based on these molecular data, several new diagnostic morphological characters such as micromorphology and microstructure of coral skeleton have been found, and the subsequent taxonomic revisions have been proposed in some scleractinian families.

The family Poritidae, which consists of the two species-rich genera *Porites* and *Goniopora* and the three monospecific genera *Stylaraea*, *Poritipora*, and *Machadoporites*, is one of the most ecologically important groups not only for coral reef region but also for non-coral reef region because it often forms huge communities, providing foods and habitats for many marine organisms. Nevertheless, the phylogenetic studies of this family have not progressed in comparison to other major families such as Acroporidae and Mussidae. In the Poritidae, molecular-based phylogenetic analyses have been performed only for *Porites*, whereas no molecular study has been done for other genus. In this study, I investigate the molecular phylogenetic relationships of the species in *Goniopora* to clarify their species boundaries. Then I also investigate the relationships among genera in the Poritidae based on the molecular and morphological analyses, to revise the classification system of the family.

## Materials and Methods

In order to identify the species of *Goniopora*, I summarized all available descriptions of the species used in this study first. In total, 31 morphospecies could be identified from 373 samples collected mainly from Japan and also from Taiwan, Malaysia, Thailand, Yemen, Djibouti, and Mayotte covering the wide range of the distribution of this genus. Molecular phylogenetic analyses were performed using nuclear and mitochondrial DNA

markers. I also applied this molecular technique to other four genera in the Poritidae. Then, these molecular data were compared with the morphological data.

## Results and Discussion

Phylogenetic trees based on both the mitochondrial and the nuclear makers show very similar topology. In both trees, only *Goniopora stokesi* and *G. stutchburyi* form a single clade, and other species do not form species-specific clades. They form totally seven clades, but the members of each clade have no morphological similarities.

*Goniopora stokesi* forms free-living colony by means of a unique asexual reproduction such as forming daughter colonies on the surface of parent colony. I observed this unique reproduction in Okinawa for the first time in Japan. I investigated this species from many other localities in Japan, but this type of reproduction occurred only in Okinawa. The present molecular and morphological analyses reveal that only the specimens in Okinawa fall into the *G. stokesi*, but those from other localities into different species.

The revealed phylogenetic mixture pattern among species with different morphological characters in each clade suggests that the morphological differences between species may occur faster than the fixation of genetic differences in species. In both the molecular trees based on mitochondrial and nuclear markers, each clade is genetically distinct, but the most species show polyphyly. This polyphyletic pattern strongly suggests the existence of cryptic species rather than an ancestral polymorphism or a hybridization.

The present analyses of the Poritidae reveal that the *Poritipora* and *Machadoporites* are included within the major *Goniopora* clades. The morphological characteristics of these two genera are overlapped with the ranges of the morphological variations of *Goniopora*. Therefore, I propose to merge these two genera with *Goniopora*. In contrast, *G. stutchburyi* is genetically distant from other *Goniopora* species and forms a sister clade with *Stylaraea* and also with *Porites*. Because *G. stutchburyi* has the intermediate morphology between *Porites* and *Goniopora* and its columella differs from that of *Goniopora*, I propose a new genus for this species.

## Conclusion

Molecular phylogenetic analyses on *Goniopora* reveal that the morphospecies identified

based on the traditional taxonomy are genetically indistinguishable. Instead they are separated into nine clades consisting of several species each. Further morphological and molecular analyses are required to classify or synonymize these species. Especially investigation of reproductive modes should be helpful for solution. On the other hand, the total analyses using molecular and morphological data revised the taxonomy of the Poritidae reflecting the phylogeny. As a result, this family becomes composed of the four genera, *Porites*, *Goniopora*, *Stylaraea*, and the new genus.